south, east, and west by a region of thunderstorm development, as though the violent discharges from highly-electrified air shaded off into gentler discharges in the distant regions, where the air was less highly electrified. A mass of air (or rather the moisture and dust contained in it) may carry a charge of electricity a great distance, and may gradually get rid of it by a series of discharges, at first violent, as in the lightning flash, but gradually diminishing, as in the luminous or phosphorescent clouds and the most brilliant forms of aurora, until finally the discharges can give rise to only the feeblest auroras. This gradual diminution in the intensity of the discharge may depend upon a corresponding gradual diminution in the quantity of vapor in the air or on a gradual change in the condition of the vapor, namely, the difference between aqueous vapor and ice vapor. In the Annual Report of the Chief Signal Officer for 1876 the present Editor has given a study of the aurora of April 7, 1874, and the following quotations, from page 309 of that volume, are here given:

(*a*) The auroral light exists sometimes as patches or clouds, but more frequently as luminous lines [more or less closely packed together] inclined to the earth's surface and approximately parallel to the free magnetic needle.

(*b*) The luminous lines are associated together, forming wave and cylindric surfaces; such surfaces appear sharply defined in the portions where their tangent planes are directed toward the observer, giving rise to the appearance of beams or streamers which are, therefore, ill defined on one edge, but sharply defined on the other.

(*c*) The luminous wave surfaces are themselves arranged parallel to each other, giving rise to arches or belts across the sky which, when the observer is favorably situated so that his lines of sight are nearly parallel to the luminous lines, are seen by him as striated belts or arches, each stria of which corresponds to an element of the wave surface, and which structure is well described by one observer as resembling the vertebrae and ribs of an animal. A slight curvature in the luminous lines, or a perspective effect, prevents the striated appearance from being well seen except near the meridian. When the luminous lines are quite straight, and especially when associated together in perfect parallelism, but without being grouped into wave surfaces, there results the corona around the magnetic zenith with "merry dancers" on all sides, as recorded by one observer. This phase of the aurora is probably best seen when the luminous lines are comparatively short.

(*d*) Inasmuch as the definite edge of a streamer is simply an optical effect produced by viewing those portions of a curved surface that lie in the tangent plane that passes to the observer, it follows that another person at a distance, viewing the same wave surface will receive from a slightly different portion thereof the impression of a definite streamer, if, indeed, he sees any at all. For a similar reason, that which appears to one person as a well defined arch or belt near his zenith will appear to an observer farther south as a collection of streamers which may, in fact, easily become so faint or ill defined as to be scarcely noticeable, while the streamers which he does observe, as such, may be formed by an entirely different set of luminous lines and surfaces. A third observer farther to the north and looking southward may, with equal ease, be observing quite a different object from either of the others. The statement is, therefore, warranted that although the auroral light emanates from definite points and lines, yet the arches and streamers made up of these have no proper locus.

(*e*) The elementary luminous lines have motions both transverse and parallel to their direction, but in addition to this, slight changes in the flexures or arrangement of the luminous surfaces, arranged, as they often are one behind the other, may give rise to a complete change in the appearance of the arches and beams. Thus it results that the movements of the arches up and down, or north and south, and the movements of the beams or striæ, take place in a manner entirely diverse from the changes going on among the luminous lines.

(*f*) A comparison of the apparent eastward and westward angular motion of the waves near the zenith of any station with the apparent nature of the streamers observed from stations farther south would, if the same objects were observed, afford an additional means of determining the average elevation of the general mass of light. The data at hand as to velocities are too crude to afford precise results in the present case. The general indications are, however, very strongly in favor of the conclusion that the luminous lines were within 10 miles of the earth.

(*g*) The electric phenomena of the atmosphere embrace on the one hand lightning attending cumulus clouds, and, on the other, the aurora attending cirrus or stratus and haze, and in both cases the electrification of the atmosphere is evidently primarily due to the inductive influence of the earth. Between these comes a third class of electric discharges, that, namely, which gives rise to the phosphorescence of clouds. Such phosphorescence was noted during the present aurora on April 7, 1874, at two stations. It has been observed by myself in Washington on occasions too numerous to enumerate, when the whole heavens were obscured and rain or snow imminent; especially has it been remarkably distinct on the edges of the banks of clouds advancing from the northwest, and immediately preceding a sudden change from warm, moist, southerly to cold, dry northerly or northwesterly winds. It has also been frequently recorded in connection with the lightning and rain of hurricanes. In fact the luminous or phosphorescent cloud due to the silent discharge of electricity between its component atoms is a far more frequent phenomenon in these latitudes than either lightning or auroras, and connects together all the luminous electric phenomena of the atmosphere in such a way as to show that while the electricity may be due to the induction of the earth, the form of the discharge is due to the state in which the atmospheric moisture exists at the time.

(*h*) It accords with the preceding views that we find the beams and arches higher above the ground and far less numerous and brilliant in the west than in the east, and that, in general, the lower Lakes and New England have ever been distinguished by brilliant auroral displays, since here not only mountains with their high electric tension, but moisture and rapid alternations of temperature predominate.

The above long quotation shows that we may expect local auroras whenever dry, cold air separates two regions of highly electrified air. The extent and brightness of the auroral display depends upon details that we can not yet enumerate.

As illustrating the weather conditions and thunderstorm phenomena over the auroral region that lay between the local storms of the Ohio Valley and the hurricane south of Cuba on the evenings of August 25 and 26, we give the following quotation from the letter of Mr. H. W. O. Margary, voluntary observer at Eustis, Lake Co., Fla.

DATA OF ELECTRICAL STORM AS SEEN FROM OBSERVATORY GROVE, EUSTIS, FLA., AUGUST 25, 1895.

6.30 p. m.—Local time. Wind light northeast. Electrical storm in southwest with constant lightning among two or more strata of clouds as if from one to the other strata, with an occasional flash to the horizon. Another dense bank of clouds slowly approaching it from the north, and also a bank high up in northeast.

7.00 p. m.—Rain began to fall in west from clouds, with clear space to horizon below, showing clearly in several places on the clear sky of western horizon. Numerous small clouds moving from different directions toward main body of clouds in southwest.

7.15 p. m.—Clouds rapidly gathering from all quarters toward the southwest; very dense; lightning in southwest and north. The chief point from which the lightning comes is a black, fleecy cloud in southwest, about 50° to 60° above the southwestern horizon. Rain increasing along western horizon in spots. Wind getting easterly but very light, at times up to 5 or 6 miles an hour. Lightning increasing in east. Wind getting puffy and very distant thunder at times, but more continuous than heretofore, and getting louder.

7.30 p. m.—Appears to be raining heavily in west-southwest and a shower in the west and northwest, but all separate; wind still light northeast to east.

7.35 p. m.—A heavy belt of black, tongue-like, ragged cloud moving up slowly from south and southeast; lightning now principally in north along horizon; three northern clouds, that passed partly to westward, seem to be absorbing the electrical clouds in southwest.

7.50 p. m.—Wind comes from west and very light, and, at 7.53, back again to east; variable from east and west; light puffs.

8.20 p. m.—Storm passing off to northwest, as the clouds from it have absorbed those in southwest and carried them to northwest; lightning still quite vivid in north.

OPTICAL PHENOMENON.

It may be interesting to publish and explain the following phenomenon, specially communicated, from the Ohio Weather and Crop Report, by Mr. Samuel W. Courtright, voluntary observer at Circleville, Ohio. He states that—

On February 12, 1895, about 9.30 p. m., a beautiful phenomenon was witnessed in the heavens, almost in the zenith. It resembled a distinct and perfect rainbow, and the moon, which had risen to a height of about 45°, was in the center of a beautiful cross of bright, light yellow bars. These bars crossed each other at right angles on the face of the moon. The horizontal bars described an arc of about one-fourth of the heavens, and at about 15° on either side of the moon was a similar cross in fainter outlines. The eastern sky was misty and heavy, while the western sky was clear and the stars shining brightly. The phenomenon was witnessed by a great many of our people.

We gather from the above report that on this occasion the principal phenomena observed were: (1) A distinct and perfect rainbow partially encircling the zenith, and so high above the moon as to be "almost in the zenith." (2) A beautiful cross of horizontal and vertical bars of a bright light yellow intersecting each other on the face of the moon. (3) Two similar fainter crosses at about 15° to the right and the left of the moon.

The general explanation of optical phenomena seen about the sun and moon was given on page 14 of this Review for January, and page 56 of this Review for February, 1895. (1) The arc of colored light or horizontal rainbow concentric with the zenith is caused by rays of sunlight that enter and leave the little vertical prisms of ice that are slowly settling down through the atmosphere. The top and bottom facets or faces of these crystals are inclined to each other and the refraction through these faces produces prismatic colors just as in an ordinary prism. The diameter of the rainbow circle around the zenith is smaller in proportion as the sun or moon is higher above the horizon. (2) The large cross of light yellow bars is due to the simple reflection of the moonlight from the outside facets of innumerable crystals of ice, all of which are slowly settling with their axes vertical. (3) The small and fainter crosses on either side of the moon are due to two reflections from the interior surfaces of crystals.

A complete study of the phenomena of parhelia can be made by preparing a number of hollow prisms made in the exact shape of the crystals of snow and ice that occur in nature. These prisms should be made of thin plates of glass cemented together at the edges, and should be filled with water, whose refractive and dispersive powers are of course very nearly the same as those of ice. Let such a prism be suspended in the sunlight in various positions with reference to the zenith, and in the position that it assumes when falling slowly through the air. Set it to revolving rapidly, as it may do when falling freely. If a special bright reflection is seen when viewed from a certain direction then this represents the position of a mock sun due to total reflection within the prism. If prismatic colors are seen this represents the position of a rainbow. If a moderately bright reflection from an external surface is seen this gives the location of some one of the numerous bands of light that may occur.

THE COLD SUMMER OF 1816.

An article in the New York Sun copied into the Iowa Monthly Review for July, 1895, gives some details about the remarkable summer of 1816, as remembered by James Winchester of Vermont. It is said that in June of that year snow fell to the depth of three inches in New York, Pennsylvania, and New Jersey on the 17th; five inches in all the New England States, except three inches in Vermont. There was snow and ice in every month of this year. The storm of June 17 was as severe as any that ever occurred in the depth of winter; it began about noon, increasing in fury until night, by which time the roads were impassable by reason of the snow drifts; many were bewildered in the blinding storm and frozen to death. During June, July, and August the wind was continuously from the north, fierce and cold; July was colder than June, and August colder than July; there was a heavy snowstorm August 30th. The first two weeks in September brought the first warm weather of the year, but on the 16th of that month the cold weather suddenly returned and continued increasing until winter. The year 1816 had neither spring, summer, nor autumn. The only crop of corn raised in that part of Vermont that summer was saved by keeping bonfires burning around the cornfield night and day. The crop of 1817 was raised from the seed of 1815. The summer of 1817 was one of the hottest and driest ever known in that region.

Note.—The preceding statement agrees with what we may gather from the interesting book by Charles Peirce, published in Philadelphia in 1847, entitled "A Meteorological Account of the Weather in Philadelphia," from January 1, 1790 to January 1, 1847. A record was begun by Peirce, at Portsmouth, N. H., in 1793, and was continued in Philadelphia, where he had access to numerous other journals. According to this work the mean temperatures at Philadelphia during the year 1816 were the lowest on record, and were as follows: January, 32°; February, 28°; March, 36°; April, 47°; May, 57°; June, 64°; July, 68°; August, 66°; September, 62°; October, 52°; November, 42°; December, 32°.

On page 247 Mr. Peirce says:

The temperature of the whole year was only 49°, it being the coldest year we have on our record. Although there was no uncommonly cold weather during the three winter months, yet there was ice during every month in the year, not excepting June, July, and August. There was scarcely a vegetable came to perfection north and east of the Potomac. The cold weather during the summer not only extended through America, but throughout Europe. One of the most celebrated meteorologists in England, on reviewing the weather of the year, said: "It would ever be remembered that 1816 was a year in which there was no summer, and the temperature of the year (as a whole) was the lowest ever known." It was also the coldest summer ever known in the West Indies and in Africa. The medium temperature of the whole year in Philadelphia was only 49°.

A POPULAR SUBSTITUTE FOR THE BAROMETER.

In The Weather and Crops, published by the Illinois State Weather Service, we find a short description of a simple instrument that serves the purpose of showing approximately the changes that may be going on in the pressure of the air. The description reads as follows:

If a large-mouthed glass jar—fruit or pickle jar will do—be filled about two-thirds full of water, and in it be placed, inverted, a smaller long-necked flask, with mouth entering the water, the increasing or decreasing pressure of the outer atmosphere will cause the water to rise or fall within the flask. Clear, fine weather will be foretold by the water rising in the flask; stormy, wet, or bad weather by the water falling.

The device thus explained will, undoubtedly, show variations in atmospheric pressure, and all the more correctly in proportion as the temperature of the air within the flask remains stationary. If we wish to be at all accurate, or if we wish not to be misled by the effects of changes of temperature we must either keep the temperature constant or else make a numerical allowance for the effect of its variations. If the temperature within the flask rises 1 degree Fahrenheit, its confined air will expand by $\frac{1}{492}$ of its volume, and the water in the neck of the flask will be pushed down to a corresponding amount. On the other hand, if the atmospheric pressure should diminish by 0.06 of an inch below a normal pressure of 30 inches, the air within the flask being slightly relieved of its pressure would expand by the $\frac{1}{492}$ part of its volume, and the water in the neck pushed down as before. In so far as we cannot rely upon the constant temperature of the air within the flask we must therefore make an allowance of 0.06 for each degree of change. As this apparatus is so sensitive to temperature it may therefore be considered as a thermometer when the atmospheric pressure is constant. In fact this is known as the first form of air thermometer which was used by the physician Sanctorius, who learned it from Galileo in 1596, and it was the study of the fluctuations of this apparatus that contributed greatly toward the discovery of the pressure of the air and the invention of mercurial barometers and the ordinary spirit thermometer. If one wishes to use this apparatus as a barometer, and needs, therefore, to know its temperature correctly to within a degree, he will find it best to fasten the smaller flask and its long neck, or, still better, a long glass tube, permanently within the outer glass jar and fill the latter with water so that the whole flask is cov-